Laboratory 2: Chronology and Dating Techniques - Radiocarbon Dating

Notes and readings on ^{14}C dating and calibration

Introduction: Radiocarbon dating is a lot more complicated than we've often been led to believe in the popular literature. The overview from Renfrew and Bahn provides some general background on the technique and the abstracts below provide some indication of the increasingly sophisticated techniques and analytical methods use in current radiocarbon assays. One of the most exciting developments is the potential pushing back of the utility of the calibration curve to nearly 50,000 years. Abstracts are provided for the papers announcing the latest 2004 calibration curve, and efforts to extend the calibration from 26,000 years to 50,000.

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[Excerpt from: *Archaeology: Theories Methods and Practice. (3rd Ed.)* Renfrew, C. and P. Bahn. London: Thames and Hudson. 2000. (pp.138-142)]

Radiocarbon Dating

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History and Basis of Method.

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Calibration of Radiocarbon Dates.

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The most recent developments in ^{14}C calibration and data analysis

The new 2004 IntCal calibration

Reimer, Paula J.; Baillie, Mike G.L.; Bard, Edouard; Bayliss, Alex; Beck, J Warren; Bertrand, Chanda J.H.; Blackwell, Paul G.; Buck, Caitlin E.; Burr, George S.; Cutler, Kirsten B.; Damon, Paul E.; Edwards, R Lawrence; Fairbanks, Richard G.; Friedrich, Michael; Guilderson, Thomas P.; Hogg, Alan G.; Hughen, Konrad A.; Kromer, Bernd; McCormac, Gerry; Manning, Sturt; Ramsey, Christopher Bronk; Reimer, Ron W.; Remmele, Sabine; Southon, John R.; Stuiver, Minze; Talamo, Sahra; Taylor, F.W.; van der Plicht, Johannes; Weyhenmeyer, Constanze E.

2004 IntCal04 Terrestrial Radiocarbon Age Calibration, 0–26 Cal Kyr BP.
Radiocarbon 46(3):1029-1058. (March 2004)

Abstract: A new calibration curve for the conversion of radiocarbon ages to calibrated (cal) ages has been constructed and internationally ratified to replace IntCal98, which extended from 0–24 cal kyr BP (Before Present, 0 cal BP = AD 1950). The new calibration data set for terrestrial samples extends from 0–26 cal kyr BP, but with much higher resolution beyond 11.4 cal kyr BP than IntCal98. Dendrochronologically-dated tree-ring samples cover the period from 0–12.4 cal kyr BP. Beyond the end of the tree rings, data from marine records (corals and foraminifera) are converted to the atmospheric equivalent with a site-specific marine reservoir correction to provide terrestrial calibration from 12.4–26.0 cal kyr BP. A substantial enhancement relative to IntCal98 is the introduction of a coherent statistical approach based on a random walk model, which takes into account the uncertainty in both the calendar age and the 14C age to calculate the underlying calibration curve (Buck and Blackwell, this issue). The tree-ring data sets, sources of uncertainty, and regional offsets are discussed here. The marine data sets and calibration curve for marine samples from the surface mixed layer (Marine04) are discussed in brief, but details are presented in Hughen et al. (this issue a). We do not make a recommendation for calibration beyond 26 cal kyr BP at this time; however, potential calibration data sets are compared in another paper (van der Plicht et al., this issue).

New statistical methods for producing calibration curves

Buck, C.E. and Blackwell, P.G.

2004 Formal Statistical Models for Estimating Radiocarbon Calibration Curves
Radiocarbon, 46(3): 1093-1102. (March 2004)

Abstract: We report on the development and implementation of a model-based statistical method for the estimation of radiocarbon calibration curves using diverse data. The method takes account of uncertainty on both the ^{14}C and calendar scales, coherently integrating data, the calendar age estimates of which arise from different dating methods. It also allows for correlation between observations, if they have particular sources of uncertainty in common. We adopt an approach based on a random walk model, tailoring it to take account of possible calendar age offsets between different data sources by adding a random effect component. The latter allows us to use the same modeling framework for constructing the new calibration curve IntCal04, the comparison curve NotCal04, the Southern Hemisphere curve SHCal04, and the marine calibration curve Marine04.

The effort to push the calibration curve to 50,000 BP

K. Hughen, S. Lehman, J. Southon, J. Overpeck, O. Marchal, C. Herring and J. Turnbull.
2004 ^{14}C Activity and Global Carbon Cycle Changes over the Past 50,000 Years
Science 303:202-207.

Abstract: A series of ^{14}C measurements in Ocean Drilling Program cores from the tropical Cariaco Basin, which have been correlated to the annual-layer counted chronology for the Greenland Ice Sheet Project 2 (GISP2) ice core, provides a high-resolution calibration of the radiocarbon time scale back to 50,000 years before the present. Independent radiometric dating of events correlated to GISP2 suggests that the calibration is accurate. Reconstructed ^{14}C activities varied substantially during the last glacial period, including sharp peaks synchronous with the Laschamp and Mono Lake geomagnetic field intensity minimal and cosmogenic nuclide peaks in ice cores and marine sediments. Simulations with a geochemical box model suggest that much of the variability can be explained by geomagnetically modulated changes in ^{14}C production rate together with plausible changes in deep-ocean ventilation and the global carbon cycle during glaciation.